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SURVEY OF TOXIC INORGANIC CONSTITUENTS IN THE ATLANTIC REGION'S AQUATIC ENVIRONMENT (1979-81)

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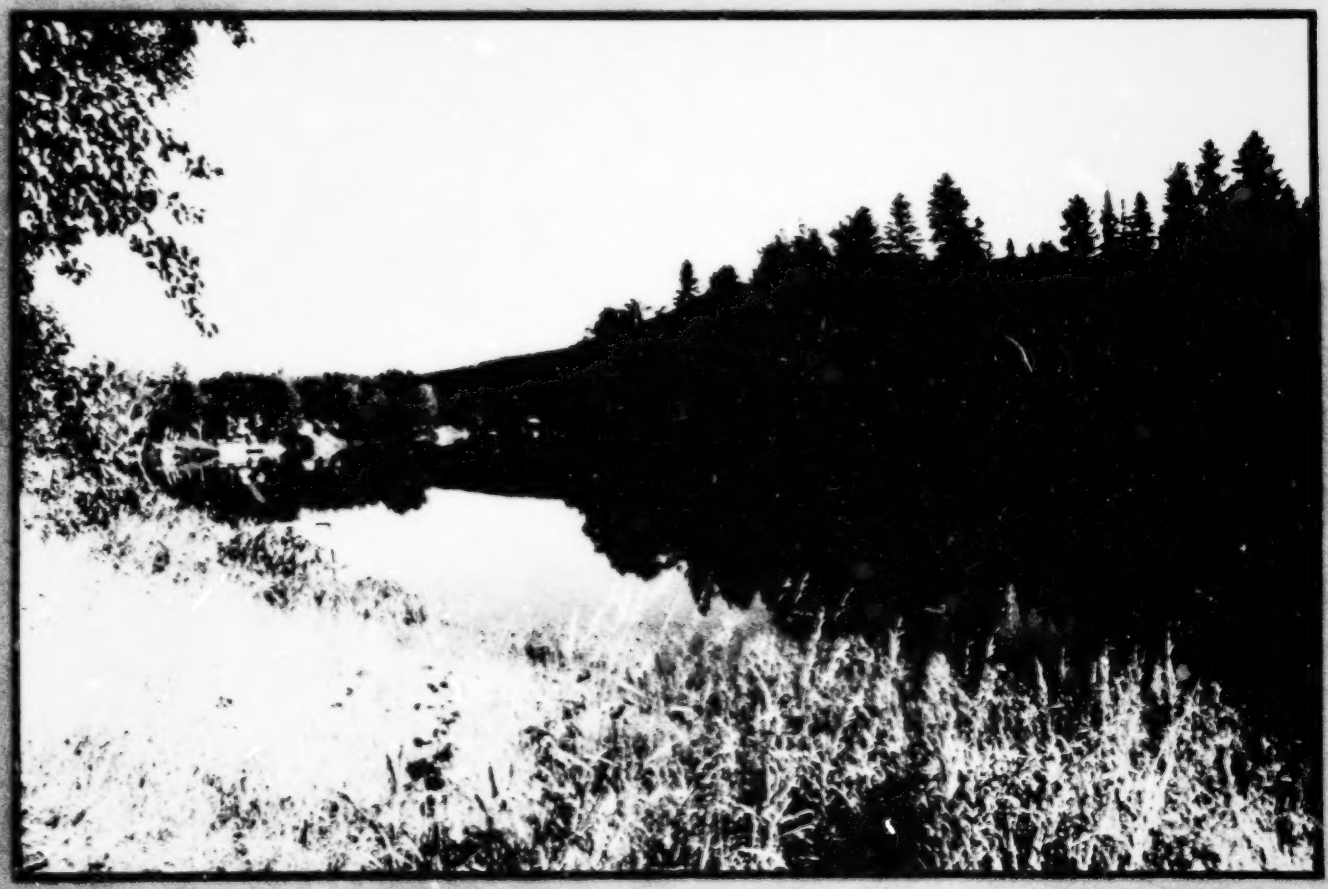

INLAND WATERS DIRECTORATE
ATLANTIC REGION
WATER QUALITY BRANCH
MONCTON, NEW BRUNSWICK

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INLAND WATERS DIRECTORATE
ENVIRONMENT CANADA

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ABSTRACT

In order to identify and quantify some of the toxic inorganic chemicals in the aquatic environment, seventy-eight sites in the Atlantic Provinces were sampled and screened for arsenic, cadmium, lead and/or mercury. This three year survey (1979-81), involving the analysis of both water and bottom sediments, resulted in the identification of a number of contaminated areas and areas requiring further scientific investigation.

RÉSUMÉ

Dans le but d'identifier certaines matières chimiques inorganiques et toxiques présentes dans le milieu aquatique et d'en déterminer la quantité, on a prélevé à soixante dix-huit endroits dans les provinces de l'Atlantique des échantillons qui ont été soumis à des tests permettant de déceler la présence d'arsenic, de cadmium, de plomb ou de mercure. Menée sur une période de trois ans (1979-1981), cette étude, qui comprenait l'analyse tant de l'eau que des sédiments marins, a donné lieu à l'identification d'un certain nombre de secteurs contaminés et de secteurs qui devront faire l'objet de recherches scientifiques plus poussées.

1. INTRODUCTION

Toxic substances have been documented to cause harmful biological effects in humans and other organisms in the environment. It has been shown that toxic substances are widely dispersed in the environment, are highly persistent, are accumulated in biological tissue and cause biological changes even in trace concentrations. Effective management of these chemical substances requires a prediction of the likely manner of their entry into the environment and scientific data on their concentration, persistence and ultimate fate.

In response to this concern, the Environmental Conservation Service of Environment Canada has developed a program with the objective of identifying and quantifying toxic chemicals and of investigating their pathways, persistence and fate in the environment.

The long term objective of the Water Quality Branch Toxic Chemicals Program, in the Atlantic Region, is to locate, characterize and quantify the extent of contamination in the aquatic environment. The results obtained can thereafter be employed by water resource managers as input to the planning, development and implementation of regulations and controls.

The aim of this study was to screen selected basins in the four Atlantic Provinces for the presence of arsenic, cadmium, lead and mercury. The media to be investigated were the water column and, in some areas, bottom sediment. The overall objective was to report on their range of concentration in the aquatic environment.

During the three year period 1979-81, a total of seventy-eight sites were sampled in triplicate with some sites being revisited two or three times. Each sample was analyzed by the Water Quality Branch Laboratory in Moncton, N.B. for one or more of the parameters under investigation. This report summarizes the results obtained by this three year survey and identifies areas where high values were observed.

2. BACKGROUND

Sampling Sites

The two main criteria employed for the selection of sampling sites were: areas perceived critical by the Water Quality Branch and areas of federal interest. The need for broad geographical coverage in each province also played an important role in the final site selection. In total, seventy-eight sites were selected with the following provincial breakdown: thirty in New Brunswick, twenty-seven in Nova Scotia, eleven in Prince Edward Island and ten in Newfoundland. A description of each sampling

site is detailed in Appendix I. In addition, this Appendix also lists the appropriate NAQUADAT station designation (1) for each of these sites. Provincial maps, identifying the location of each site sampled, are also appended.

Sampling Program

The sampling program consisted of three phases, each covering one year of the three year survey. The number of sites selected for each phase was highly dependent on the amount of financial resources available during that particular year. In phase I (1979) thirty-six sampling sites were visited while in phase II (1980) forty-four sites were sampled. Finally, in phase III (1981), samples were collected from twenty-eight sites. The sampling distribution by Province for each phase is listed in Table 1.

TABLE 1

SITES SAMPLED

PROVINCE	PHASE I (1979)	PHASE II (1980)	PHASE III (1981)
New Brunswick	15	13	12
Nova Scotia	15	15	11
Prince Edward Island	6	6	5
Newfoundland	Nil	10	Nil

Sampling in each phase was conducted in late summer or early fall and consisted of collecting triplicate water samples and, if present, triplicate bottom sediment samples.

Parameters

The four toxic inorganic constituents selected for this survey were arsenic, cadmium, lead and mercury. The parameter selection was based on Environment Canada's Priority Chemical List, data needs in the Atlantic Region and availability of approved Water Quality Branch analytical methodology. The actual parameters analyzed, in each Phase of the survey, are given in Table 2.

TABLE 2

PARAMETERS ANALYZED IN EACH PHASE

MEDIA	PHASE I (1979)	PHASE II (1980)	PHASE III (1981)
Water	Arsenic Lead	Lead	Arsenic
Bottom Sediment	Cadmium	Cadmium Mercury	Cadmium Lead

The number of parameters analyzed in each Phase was restricted by the amount of Water Quality Branch resources available for the survey in each fiscal year.

Field Methodology

Water samples were collected, at a depth of approximately 0.3 m below the surface, in polyethylene plastic bottles using a triplicate iron sampler. The sample volumes were 250 mL for the arsenic samples and 500 mL for the lead samples. The lead samples were immediately preserved in the field with 1 mL of concentrated nitric acid while the arsenic samples were left unpreserved.

Bottom sediment samples were collected using a 15 x 15 cm Ekman Grab Sampler. Once collected, the sediment sample was carefully released from the sampler into a clean Pyrex tray. The sediment was subsequently sub-sampled by taking approximately 0.5 kg of the top 1.0-2.5 cm with an aluminum scoop. This sub-sample was placed in a pre-washed mason jar (1979) or a Reynolds® Aluminum Freezer Storage container (1980 and 1981). The whole sampling and sub-sampling procedure was repeated until three independent bottom sediment samples had been collected. During the first year (1979), the sediment samples were stored in a cool dry place while being transported to the Water Quality Branch Laboratory. On the other hand, in 1980 and 1981 the samples were stored in a mobile laboratory freezer until they reached their destination.

All water and sediment samples were returned to the Water Quality Branch Laboratory within four days of their collection except those originating from Newfoundland which were returned within nine days.

Laboratory Methodology

All analyses were performed using the standard analytical procedures described in the Water Quality Branch Analytical Methods Manual (2). The specific methods employed, which are identified by their respective NAQUADAT Parameter codes (3), are summarized as follows:

a) Arsenic in water

The arsenic levels in water samples were determined using either method 33006L or 33007L. Method 33006L involves reducing the inorganic arsenic in the sample to arsine using zinc and hydrochloric acid. The arsine is then passed through a lead acetate scrubber and absorbed in a silver diethyl dithiocarbamate solution. The resulting red soluble complex is subsequently spectrophotometrically measured at 540 nm. The detection limit is 0.005 mg/L.

Method 33007L involves reducing the inorganic arsenic to a hydride using $NaBH_4$ and determining the concentration by flameless atomic absorption at 193 nm. The detection limit is 0.0005 mg/L.

b) Cadmium in sediment

Cadmium in sediment was determined using method 48054L. This method consists of extracting the sediment in 0.5 m hydrochloric acid followed by a direct aspiration atomic absorption measurement at 228.8 nm. The detection limit is 0.1 mg/kg.

c) Lead in water

Lead in water samples was determined using method 82302P. In this method the sample is acidified with nitric acid and the lead is chelated with ammonium pyrrolidine dithiocarbamate. After extraction with methyl isobutyl ketone, the absorbance is measured spectrophotometrically by atomic absorption at 283.3 nm. The detection limit is 0.002 mg/L.

d) Lead in sediment

Lead in sediment was determined using method 82054L. This method is identical to the one described for cadmium in sediment (48054L) except that the absorbance is measured at 283.3 nm. The detection limit is 0.5 mg/kg.

e) Mercury in sediment

Mercury was determined using method 80052L. In this method, the sediment is finely suspended in distilled water, homogenized, and digested with sulfuric acid and

dichromate under UV oxidizing conditions. Hydroxylamine hydrochloride and stannous chloride are then added to the slurry. The absorbance of elemental mercury sparged from the slurry is measured by flameless atomic absorption at 253.7 nm. The detection limit is 0.02 mg/kg.

3. ARSENIC

General

In Canada, the dissolved arsenic concentration in over 5,400 river water samples collected between 1972 and 1977 ranged from less than 0.01 mg/L to approximately 0.05 mg/L (4). The major sources of arsenic are mineral dissolution, industrial discharges and the application of arsenic based pesticides. Arsenic is also a by-product of copper and lead ore smelting. Industrial processes using arsenic include the manufacture of glass, pigments, textiles, paper, metal adhesives, ceramics, wood preservatives, paints and electrical semi-conductors. The combustion of fossil fuels also releases arsenic to the atmosphere.

In order to protect man, arsenic in drinking water should not exceed 0.05 mg/L (5). Other guidelines for use protection include 0.5 mg/L for livestock watering, 0.2-1.0 mg/L for irrigation water and 0.05 mg/L for aquatic life (4).

Results

Water samples were collected for arsenic analysis during phase I (1979) and phase III (1981) of the survey. In total, twenty-five triplicate samples were collected in New Brunswick,

eighteen in Nova Scotia and eleven in Prince Edward Island. The results are listed in Table 3.

Discussion

In 1979, while employ ng an analytical technique with a detection limit of 0.005 mg/L (Method 33006L), arsenic was found in three of the thirty-two sites sampled, while in 1981, with a change in methodology which lowered the detection limit to 0.005 mg/L (Method 33007L), eleven of the twenty-two sites sampled gave positive results. In total, fourteen of the fifty-four sites had measurable levels of arsenic. The positive values, however, were lower than any of the aforementioned use protection guidelines. Arsenic cannot therefore be considered a problem parameter at any of the sites surveyed.

4. CADMIUM

General

Cadmium is usually only found in trace quantities in the aquatic environment with the highest concentration accumulated in the sediment. The maximum concentrations are normally 0.01 mg/L for fresh water and 0.0001 mg/L for seawater (6). Anthropogenic sources include mining and smelting of zinc, lead and copper and fertilizers used in agriculture.

TABLE 3

ARSENIC IN WATER

STATION	CONCENTRATION (mg/L)[a]						AVERAGE
	PHASE I (1979)			PHASE III (1981)			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #1	SAMPLE #2	SAMPLE #3	
NEW BRUNSWICK							
1	-	-	-	NIL	NIL	NIL	0
2	-	-	-	NIL	NIL	NIL	0
3	NIL	NIL	NIL	-	-	-	0
4	-	-	-	NIL	NIL	NIL	0
5	NIL	NIL	NIL	-	-	-	0
6	-	-	-	NIL	NIL	NIL	0
7	NIL	NIL	NIL	-	-	-	0
8	-	-	-	NIL	NIL	NIL	0
9	-	-	-	NIL	NIL	NIL	0
10	NIL	NIL	NIL	-	-	-	0
11	-	-	-	NIL	NIL	-	0
12	-	-	-	NIL	0.0005	NIL	0.00017
13	0.005	NIL	NIL	-	-	-	0.00170
15	-	-	-	NIL	NIL	NIL	0
16	NIL	NIL	NIL	-	-	-	0
18	-	-	-	NIL	NIL	NIL	0
19	NIL	NIL	NIL	-	-	-	0
20	NIL	NIL	NIL	-	-	-	0
21	-	-	-	NIL	NIL	NIL	0
22	NIL	NIL	NIL	-	-	-	0
25	NIL	NIL	NIL	-	-	-	0
26	NIL	NIL	NIL	-	-	-	0
27	NIL	NIL	NIL	-	-	-	0
29	NIL	NIL	NIL	-	-	-	0
30	-	-	-	0.0005	0.0006	0.0005	0.00053

TABLE 3 Cont'd

STATION	CONCENTRATION (mg/L)[a]						AVERAGE
	PHASE I (1979)			PHASE III (1981)			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #1	SAMPLE #2	SAMPLE #3	
NOVA SCOTIA							
31	NIL	NIL	NIL	-	-	-	0
32	NIL	NIL	NIL	-	-	-	0
33	NIL	NIL	NIL	-	-	-	0
34	-	-	-	0.0005	0.0006	0.0005	0.00053
35	-	-	-	0.0005	0.0007	0.0005	0.00057
36	NIL	NIL	NIL	-	-	-	0
38	NIL	NIL	NIL	-	-	-	0
40	NIL	NIL	NIL	-	-	-	0
42	-	-	-	NIL	NIL	NIL	0
43	-	-	-	NIL	NIL	0.0007	0.00023
45	NIL	NIL	NIL	-	-	-	0
46	-	-	-	0.0010	0.0008	0.0007	0.00083
48	NIL	NIL	NIL	-	-	-	0
49	NIL	NIL	NIL	-	-	-	0
50	0.005	0.005	0.005	-	-	-	0.00500
52	NIL	NIL	NIL	-	-	-	0
55	NIL	NIL	NIL	-	-	-	0
57	0.005	0.005	0.005	-	-	-	0.00500
PRINCE EDWARD ISLAND							
58	NIL	NIL	NIL	-	-	-	0
59	-	-	-	0.0009	0.0009	0.0009	0.00090
60	NIL	NIL	NIL	-	-	-	0
61	NIL	NIL	NIL	-	-	-	0
62	NIL	NIL	NIL	-	-	-	0
63	-	-	-	0.0007	0.0008	0.0008	0.00077
64	-	-	-	0.0005	NIL	NIL	0.00017
65	-	-	-	0.0006	0.0009	0.0006	0.00070
66	NIL	NIL	NIL	-	-	-	0
67	NIL	NIL	NIL	-	-	-	0
68	-	-	-	0.0008	0.0007	0.0005	0.00067

a The dash (-) indicates that either the site was not sampled or the sample was not analyzed.

The combustion of fossil fuels may also release small quantities of cadmium to the atmosphere. Industrial processes using cadmium include the manufacture of pigments, nickel-cadmium batteries, solder, electronic equipment, lubricants, photographic equipment, glass, ceramics, biocides, fertilizers and some plastics.

The only guideline available for cadmium in sediment is the one contained in the Ocean Dumping Control Act which limits cadmium to 0.6 mg/kg. For comparative purposes, use protection guidelines for cadmium in water include the following: 0.05 mg/L for drinking (5), 0.02 mg/L for livestock watering (7), 0.01 mg/L for irrigation waters (7), and 0.0002 mg/L for aquatic life.

Results

Bottom sediment samples were collected for cadmium analysis during the three phases of the survey. In total, twenty-three triplicate samples were collected from twenty sites in New Brunswick, twenty-four triplicate samples from nineteen sites in Nova Scotia, eleven triplicate samples from eight sites in Prince Edward Island and four triplicate samples from four sites in Newfoundland. A few of the samples collected were not analyzed due to loss or contamination at some step in the process. The results are detailed in Table 4.

TABLE 4

CADMIUM IN SEDIMENT

STATION	CONCENTRATION (mg/kg)[a]									AVERAGE
	PHASE I (1979)			PHASE II (1980)			PHASE III (1981)			
	SAMPLE			SAMPLE			SAMPLE			
	#1	#2	#3	#1	#2	#3	#1	#2	#3	
NEW BRUNSWICK										
1	-	-	-	-	-	-	NIL	NIL	NIL	0
4	0.15	0.10	0.20	-	-	-	0.17	0.17	0.19	0.163
5	0.23	0.20	0.19	-	-	-	-	-	-	0.207
6	-	-	-	-	-	-	0.53	0.60	0.60	0.577
7	0.25	0.14	0.29	0.44	0.16	0.11	-	-	-	0.230
8	-	-	-	-	-	-	0.24	0.28	0.21	0.243
9	-	-	-	-	-	-	0.21	0.28	0.21	0.233
11	-	-	-	-	-	-	NIL	NIL	NIL	0
12	-	-	-	-	-	-	0.16	0.10	0.16	0.140
13	NIL	0.01	NIL	-	-	-	-	-	-	0.003
15	-	-	-	-	-	-	0.55	0.59	0.60	0.580
18	-	-	-	-	-	-	0.97	0.92	0.90	0.930
20	0.20	0.50	0.24	0.97	0.69	0.70	-	-	-	0.550
21	-	-	-	-	-	-	1.4	1.5	1.4	1.433
22	2.5	-	-	-	-	-	-	-	-	2.500[b]
24	-	-	-	1.4	0.93	1.2	-	-	-	1.177
25	0.86	0.90	1.4	-	-	-	-	-	-	1.053
28	-	-	-	1.2	1.8	1.6	-	-	-	1.533
29	0.10	1.7	0.10	-	-	-	-	-	-	0.633
30	-	-	-	-	-	-	NIL	NIL	0.1	0.033
NOVA SCOTIA										
32	0.15	0.15	0.15	NIL	NIL	-	-	-	-	0.075
34	-	-	-	-	-	-	2.1	2.0	2.3	2.133
35	-	-	-	-	-	-	0.56	0.80	0.72	0.693
36	0.11	0.10	0.14	-	-	-	-	-	-	0.117

Table 4 Cont'd

STATION #	CONCENTRATION (mg/kg) [a]									AVERAGE
	PHASE I (1979)			PHASE II (1980)			PHASE III (1981)			
	SAMPLE			SAMPLE			SAMPLE			
	#1	#2	#3	#1	#2	#3	#1	#2	#3	
39	-	-	-	-	-	-	0.47	0.39	-	0.430
40	0.33	0.30	0.30	-	-	-	-	-	-	0.310
41	-	-	-	-	-	-	0.45	0.34	-	0.395
42	-	-	-	-	-	-	0.23	0.27	0.27	0.257
43	-	-	-	-	-	-	0.27	0.33	0.32	0.307
44	-	-	-	0.15	0.25	0.18	-	-	-	0.193
46	-	-	-	-	-	-	0.22	0.23	0.25	0.233
47	-	-	-	0.20	0.23	0.22	-	-	-	0.217
48	0.30	0.38	0.38	0.25	0.25	0.25	-	-	-	0.302
50	NIL	NIL	NIL	NIL	NIL	NIL	-	-	-	0
51	-	-	-	-	-	-	0.89	0.86	0.94	0.897
53	0.80	0.65	0.72	0.71	0.77	0.72	-	-	-	0.728
54	NIL	0.10	NIL	-	-	-	-	-	-	0.033
56	-	-	-	-	-	-	2.9	2.8	2.9	2.833
57	2.0	1.5	1.6	1.5	1.9	1.5	-	-	-	1.667
PRINCE EDWARD ISLAND										
59	-	-	-	-	-	-	0.21	0.24	0.21	0.220
61	NIL	NIL	NIL	NIL	NIL	NIL	-	-	-	0
62	NIL	0.20	0.20	0.48	0.48	0.45	-	-	-	0.302
63	-	-	-	-	-	-	0.66	0.66	0.61	0.643
64	-	-	-	-	-	-	0.19	0.33	0.24	0.253
65	-	-	-	-	-	-	0.29	0.24	0.21	0.247
66	0.25	0.30	0.30	0.21	0.11	0.06	-	-	-	0.205
68	-	-	-	-	-	-	0.47	0.59	0.45	0.503
NEWFOUNDLAND										
71	-	-	-	0.58	0.68	0.48	-	-	-	0.580
72	-	-	-	0.60	0.95	0.57	-	-	-	0.707
75	-	-	-	0.19	-	-	-	-	-	0.190 [b]
78	-	-	-	1.6	1.6	-	-	-	-	1.600

a The dash (-) indicates that either the site was not sampled or the sample was not analyzed.

b Only one sample analyzed therefore results cannot be verified.

Discussion

In New Brunswick eighteen of the twenty sites sampled were found to contain cadmium. The highest concentration was found at site #23 (Nepisiquit River), however, since only one sample was analyzed, the confidence of this result cannot be ascertained. Neglecting the aforementioned result, the provincial range of positive values was 0.01 - 1.5 mg/kg with an average cadmium concentration of 0.511 mg/kg for all sites surveyed. High values (above 1.0 mg/kg) were observed for the Nepisiquit River, Bathurst Harbour, and the Miramichi River near Chatham. These high values can be attributed to the mining operations in Northeastern New Brunswick. Two other sites, Spednic Lake and the Miramichi River near Loggieville, had average concentrations between 0.6 - 1.0 mg/kg, although the latter site did not show consistency in the triplicate samples collected in 1979 (0.1, 1.7 and 0.1).

The results from Nova Scotia were quite similar to those from New Brunswick. Eighteen of the nineteen sites sampled were found to contain measurable levels of cadmium. The highest value observed was 2.9 mg/kg for the Mira River. The provincial range of positive values was 0.1 - 2.9 mg/kg with an average cadmium concentration of 0.622 mg/kg for all sites surveyed. Aside from the Mira River, high values (above 1.0 mg/kg) were observed for the Shubenacadie Lake (inlet) and

Sydney Harbour. These high values can probably be attributed to old and current mining operations and to the steel mill in Sydney. Three other sites, Shubenacadie Lake (outlet), Strait of Canso and Lake Ainslie, had average concentrations of cadmium between 0.6 - 1.0 mg/kg.

In Prince Edward Island, the results were quite different. Seven of the eight sites sampled were found to contain measurable levels of cadmium but the provincial average was only 0.297 mg/kg. The highest value obtained was 0.66 mg/kg at New London Bay and the provincial range of positive values was 0.06 - 0.66 mg/kg.

The results from Newfoundland were closer to those found in New Brunswick and Nova Scotia. Although only four sites were sampled, all were found to contain measurable levels of cadmium. The highest value observed was 1.6 mg/kg for the St. John's Harbour. The provincial range of positive values was 0.19 - 1.6 mg/kg with an average cadmium concentration of 0.769 mg/kg for all sites surveyed. Aside from St. John's Harbour, Humber Arm was also found to have cadmium levels greater than 0.6 mg/kg.

In total, forty-seven of the fifty-one sites sampled gave positive cadmium results. The overall range of positive values was 0.01 - 2.9 mg/kg with an average cadmium concentration of 0.539 mg/kg for the fifty-one sites surveyed. It should be noted that many sites exceed the Ocean Dumping Act (1975) guideline of 0.6 mg/kg.

5. LEAD

General

Lead is ubiquitous in the aquatic environment and may be found in both soluble and suspended forms in water. Natural waters seldom contain high lead concentrations. Waters draining regions of sulfide ores which contain lead may exhibit concentrations of 0.4 to 0.8 mg/L, however, most other surface waters typically contain only a trace to 0.04 mg/L (6). Although lead concentrations vary in sediment, typical values previously reported include 0.026 mg/kg in the Ottawa River and 0.042 mg/kg in the Rideau River (8).

The principal natural source of lead is the weathering of sulfide ores. Anthropogenic sources include the burning of leaded fuels, ore smelting, production of batteries, lead pipes and motor oils. In addition, lead salts are used in the printing and dyeing operations, photography, engraving and in the manufacture of explosives (6).

In sediment, sorption and bacterial processes appear to exert dominant effects on the distribution of lead. Benthic microbes in laboratory studies, have been shown to methylate lead to form tetramethyl lead which is more volatile and more toxic than inorganic lead (9). These processes enable lead in the sediment to be reintroduced to the aqueous environment thereby creating a dynamic system of dissolution and absorption/precipitation.

In order to protect man, lead in drinking water should not exceed 0.25 mg/L. Other guidelines for use protection include 0.5 mg/L for livestock watering, 5 mg/L for irrigation water and 0.01 mg/L for aquatic life (10). There do not appear to be any protection guidelines for lead in sediment.

Results

Water samples were collected for lead analysis during Phase I (1979) and Phase II (1980) of the survey. In total twenty-six triplicate water samples were collected in New Brunswick, twenty-eight in Nova Scotia, twelve in Prince Edward Island and ten in Newfoundland. The results are shown in Table 5.

Bottom sediment samples were only collected for lead analysis in Phase III (1981). Altogether eleven triplicate sediment samples were collected in New Brunswick, ten in Nova Scotia and five in Prince Edward Island. The results are listed in Table 6.

Discussion

Lead was found in the water samples from twenty-five of the forty-nine sites surveyed. The positive lead values ranged from 0.002 to 0.01 mg/L and the average (0.0007 mg/L) for all sites sampled was below the detection limit. All positive

TABLE 5

LEAD IN WATER

STATION #	CONCENTRATION (mg/L) [a]						Averag
	PHASE I (1979)			Phase II (1980)			
	Sample			Sample			
	#1	#2	#3	#1	#2	#3	
NEW BRUNSWICK							
3	0.002	NIL	NIL	NIL	NIL	NIL	0.0003
5	0.002	NIL	NIL	NIL	NIL	NIL	0.0003
7	NIL	NIL	NIL	NIL	0.002	NIL	0.0003
10	NIL	NIL	NIL	0.002	0.002	NIL	0.0006
13	0.006	0.006	0.007	-	-	-	0.0063
14	-	-	-	NIL	NIL	NIL	0
16	0.002	NIL	NIL	NIL	NIL	NIL	0.0003
19	NIL	NIL	NIL	NIL	NIL	NIL	0
20	NIL	NIL	NIL	NIL	NIL	NIL	0
22	0.002	NIL	NIL	NIL	NIL	NIL	0.0003
24	-	-	-	NIL	NIL	NIL	0
25	0.002	NIL	NIL	-	-	-	0.0006
26	NIL	NIL	NIL	NIL	NIL	NIL	0
27	NIL	NIL	NIL	NIL	NIL	NIL	0
28	-	-	-	0.010	NIL	NIL	0.0033
29	NIL	NIL	NIL	-	-	-	0
NOVA SCOTIA							
31	NIL	NIL	NIL	NIL	NIL	NIL	0
32	0.004	NIL	NIL	NIL	NIL	NIL	0.0006
33	NIL	NIL	NIL	NIL	NIL	NIL	0
36	NIL	NIL	NIL	-	-	-	0
37	-	-	-	0.002	0.002	0.002	0.0020
38	NIL	NIL	NIL	NIL	NIL	NIL	0
40	0.002	NIL	NIL	-	-	-	0.0006
44	-	-	-	NIL	NIL	NIL	0

STATION #	CONCENTRATION (mg/L) [a]						
	PHASE I (1979)			PHASE II (1980)			AVERAGE
	SAMPLE			SAMPLE			
	#1	#2	#3	#1	#2	#3	
45	0.002	0.005	NIL	NIL	NIL	NIL	0.0012
47	-	-	-	NIL	NIL	NIL	0
48	0.004	0.004	0.005	NIL	NIL	NIL	0.0022
49	NIL	NIL	0.002	NIL	NIL	NIL	0.0003
50	0.002	0.003	0.004	NIL	0.003	0.002	0.0023
52	0.002	0.003	NIL	NIL	NIL	NIL	0.0008
53	-	-	-	NIL	NIL	NIL	0
55	NIL	NIL	NIL	0.002	0.002	0.003	0.0012
57	NIL	NIL	NIL	0.002	0.002	NIL	0.0006
PRINCE EDWARD ISLAND							
58	NIL	NIL	NIL	NIL	NIL	NIL	0
60	NIL	NIL	NIL	NIL	NIL	NIL	0
61	NIL	NIL	NIL	NIL	NIL	NIL	0
62	NIL	NIL	NIL	NIL	NIL	NIL	0
66	NIL	NIL	NIL	NIL	NIL	NIL	0
67	NIL	NIL	NIL	NIL	NIL	NIL	0
NEWFOUNDLAND							
69	-	-	-	0.002	0.002	NIL	0.0013
70	-	-	-	NIL	0.002	0.002	0.0013
71	-	-	-	0.003	NIL	NIL	0.0010
72	-	-	-	NIL	0.002	NIL	0.0006
73	-	-	-	NIL	NIL	NIL	0
74	-	-	-	0.002	0.003	0.002	0.0023
75	-	-	-	NIL	NIL	NIL	0
76	-	-	-	NIL	NIL	NIL	0
77	-	-	-	NIL	NIL	NIL	0
78	-	-	-	0.005	0.004	0.004	0.0043

a The dash (-) indicates that either the site was not sampled or the sample was not analyzed.

TABLE 6

LEAD IN SEDIMENT

STATION #	CONCENTRATION (mg/kg)[a] PHASE III (1981) SAMPLE #1	SAMPLE #2	SAMPLE #3	AVERAGE
New Brunswick				
1	5.0	5.0	5.0	5.0
4	14.0	14.0	16.0	14.7
6	45.0	29.0	30.0	34.7
8	28.0	27.0	28.0	27.7
9	12.0	12.0	12.0	12.0
11	30.0	30.0	31.0	30.3
12	34.0	32.0	34.0	33.3
15	33.0	34.0	34.0	33.7
18	58.0	58.0	55.0	57.0
21	38.0	34.0	50.0	40.7
30	9.4	9.4	9.4	9.4
Nova Scotia				
34	110.0	93.0	76.0	93.0
35	25.0	36.0	29.0	30.0
39	41.0	37.0	-	39.0
41	35.0	31.0	-	33.0
42	40.0	41.0	42.0	41.0
43	35.0	32.0	36.0	34.3
46	34.0	40.0	40.0	38.0
51	44.0	35.0	42.0	40.3
54	18.0	14.0	13.0	15.0
56	80.0	86.0	88.0	84.6
PRINCE EDWARD ISLAND				
59	12.0	11.0	15.0	12.7
63	17.0	17.0	18.0	17.3
64	20.0	19.0	20.0	19.7
65	20.0	19.0	17.0	18.7
68	17.0	17.0	16.0	16.7

a. The dash (-) indicates that either the site was not sampled or the sample was not analyzed.

results were much lower than any of the use protection guidelines. It may therefore be concluded that lead is not a problem parameter in any of the waters sampled.

All twenty-six sites sampled for bottom sediment exhibited positive lead results. These lead values were much higher than the levels reported for the Ottawa and Rideau Rivers (8). In New Brunswick, the provincial range for lead in sediment was from 5.0 to 58.0 mg/kg with an average concentration of 27.1 mg/kg. Samples collected in Nova Scotia gave slightly higher results. The Nova Scotia values ranged from 13.0 to 110.0 mg/kg with an average concentration of 44.8 mg/kg. In contrast, samples collected in Prince Edward Island gave slightly lower results. The Prince Edward Island provincial range was from 11.0 to 20.0 mg/kg with an average concentration of 17.0 mg/kg. In total, the survey range for lead in sediment was from 5.0 to 110.0 mg/kg with an overall average concentration of 32.0 mg/kg. This is typical of crustal concentrations (10) and comparable to results obtained for the Great Lakes (11).

6. MERCURY

General

Mercury is a trace metal in the earth's crust and occurs in only minor quantities in natural waters. It is common, however, for mercury to be sorbed to particulate matter and concentrated in the sediment. Concentrations of mercury in

uncontaminated freshwater systems are typically 0.05 ug/L. Seawater, on the other hand, usually contains a concentration of only 0.03 ug/L (6). The average concentration of mercury in freshwater sediments has been reported to be approximately 0.073 mg/kg, while oceanic sediments are generally 0.01 mg/kg(12).

The most common natural source of mercury is cinnabar (HgS). A number of sulfide minerals also contain mercury. Mercury compounds are used in a number of commercial and industrial processes such as the chlor-alkali process and pulp and paper milling. Other applications involving mercury include the manufacture of paints, electrical equipment, mercury vapour lamps, dental amalgams and some drugs.

In order to protect man, mercury in drinking water should not exceed 0.001 mg/L (13). Other guidelines for use protection include 0.003 mg/L for livestock watering and 0.1 ug/L for aquatic life (13). The only standard available for mercury in sediment is found in the Ocean Dumping Control Act (1975) which limits mercury to 0.75 mg/kg (14). It has been suggested however, that mercury levels in sediment exceeding 0.1 mg/kg should be considered as enriched by either geologic or anthropogenic sources (14).

Results

Bottom sediment samples were collected for mercury analysis during phase II (1980) of the survey. In total, seven triplicate

sediment samples were collected in New Brunswick, seven in Nova Scotia, three in Prince Edward Island and four in Newfoundland. A few of the samples collected were not analyzed due to loss or contamination at some step in the process. The results are listed in Table 8.

Discussion

All twenty-one sites sampled exhibited positive mercury results. The highest value obtained was at Sydney Harbour and the lowest was at Chedabucto Bay. In New Brunswick, the concentration of mercury in sediments ranged from 0.04 to 0.48 mg/kg with an average concentration of 0.183 mg/kg. Samples from Nova Scotia gave higher results. The positive values in Nova Scotia ranged from 0.02 to 2.22 mg/kg with an average concentration of 0.467 mg/kg. In Prince Edward Island the concentration of mercury in sediments ranged from 0.03 to 0.63 mg/kg with an average concentration of 0.243 mg/kg. Finally, samples from Newfoundland ranged from 0.03 to 0.95 mg/kg with an average concentration of 0.339 mg/kg. The average concentration of mercury in sediment for all sites sampled in the Atlantic Provinces was 0.316 mg/kg.

Only one site exceeded the Ocean Dumping Control limit of 0.75 mg/kg and that was the site in the Sydney Harbour. This site can definitely be considered contaminated. Thirteen of the twenty-one sites, however, exceeded the 0.1 mg/kg

TABLE 8

MERCURY IN SEDIMENT

STATION #	CONCENTRATION (mg/kg)[a] PHASE II (1980) SAMPLE #1	SAMPLE #2	SAMPLE #3	AVERAGE
NEW BRUNSWICK				
5	0.04	0.08	0.04	0.053
7	0.44	0.16	0.11	0.237
14	0.14	0.08	0.03	0.083
17	0.48	0.32	0.40	0.287
20	0.15	0.22	0.24	0.203
24	0.22	0.22	0.18	0.207
28	0.24	0.21	0.19	0.213
NOVA SCOTIA				
32	0.44	0.35	0.20	0.330
44	0.12	0.16	0.43	0.237
47	0.31	0.44	0.29	0.347
48	0.57	0.49	0.60	0.553
50	NIL	NIL	0.02	0.007
53	0.13	0.03	0.08	0.080
57	1.42	2.22	1.50	1.713
PRINCE EDWARD ISLAND				
61	-	0.03	-	0.030
62	0.06	0.12	0.09	0.090
66	0.63	0.57	0.63	0.610
NEWFOUNDLAND				
71	0.07	0.03	0.03	0.043
72	0.28	0.05	0.95	0.427
75	-	0.03	-	0.030
78	-	0.86	0.85	0.855

a The dash (-) indicates that sample was not analyzed.

alert level recommended by Wilson and Travers (11), indicating the possibility of anthropogenic pollution. Seventeen of the twenty-one sites also had average concentrations higher than the national averages of 0.73 mg/kg for freshwater sediments and 0.01 mg/kg for seawater sediments reported by Jonasson and Boyle (12).

CONCLUSIONS

The purpose of this study was to locate and quantify the extent of arsenic, cadmium, lead and mercury concentration in the aquatic environment. Eighty-four sites were surveyed over a three year period and the resulting data show that:

1) Arsenic was not a problem in any of the waters sampled,

2) Cadmium concentrations were high in a number of sediment samples. Problem areas were identified as northeastern New Brunswick waters, Spednic Lake (N.B.), Mira River (N.S.), Strait of Canso (N.S.), Lake Ainslie (N.S.), New London Bay (P.E.I.), St. John's Harbour (Nfld.) and Humber Arm (Nfld.).

3) Lead was not a problem in any of the waters sampled but most sediment samples contained lead concentrations higher than those previously reported for the Ottawa and the Rideau Rivers.

4) Mercury concentrations in sediments were very high for Sydney Harbour. In addition, twelve other sites had values above the alert level of 0.1 mg/kg.

CREDITS

In addition to the authors, the following Water Quality Branch staff participated in this study: D. Lockerbie, V. Komadina, H. Islam and G. Norton.

REFERENCES

(1) NAQUADAT Users Manual; A. Demayo and E. Hunt, Water Quality Branch, Inland Waters Directorate, Ottawa, Ont. (1975).

(2) Analytical Methods Manual; Water Quality Branch, Inland Waters Directorate, Ottawa, Ont. (1979).

(3) NAQUADAT Dictionary of Parameter Codes; S.H. Whitlow, Data & Instrumentation Section, Water Quality Branch, Environment Canada (1982).

(4) Guidelines for Surface Water Quality, Vol. 1 - Inorganic Chemical Substances: Arsenic; A. Demayo, M.C. Taylor and S.W. Reeder, Water Quality Branch, Inland Waters Directorate, Ottawa, Ont. (1979).

(5) Guidelines for Canadian Drinking Water Quality 1978; Federal-Provincial Working Group on Drinking Water, Department of National Health and Welfare (1979).

(6) Water Quality Sourcebook - A Guide to Water Quality Parameters; R.N. McNeely, V.P. Neimanis and L. Dwyer, Water Quality Branch, Inland Waters Directorate, Ottawa, Ont. (1979).

(7) Guidelines for Surface Water Quality, Vol. 1 - Inorganic Chemical Substances: Cadmium; S.W. Reeder, A. Demayo and M.C. Taylor, Water Quality Branch, Inland Waters Directorate, Ottawa, Ont. (1979).

(8) Environmental Contaminants Inventory Study No. 3 - The Production, Use and Distribution of Lead in Canada; T.D. Leah, Report Series No. 41, Water Planning & Management Branch, Inland Waters Directorate, Burlington, Ont. (1976).

(9) Water-Related Environmental Fate of 129 Priority Pollutants; EPA-440/4-79-029a, U.S. EPA, Washington, D.C. (1979).

(10) Guidelines for Surface Water Quality, Vol. 1 - Inorganic Chemical Substances: Lead; A. Demayo, M.C. Taylor, and S.W. Reeder, Water Quality Branch, Inland Waters Directorate, Ottawa, Ont. (1980).

(11) Heavy Metal Concentrations and Distributions in River Mouth Sediments around the Great Lakes; T.C. Hutchinson and J. Zitchko, In Proc. Int. Conf. on Transport of Persistent Chemicals in Aquatic Ecosystems. Ottawa, Ont. pp 69-77 (1979).

(12) Geochemistry of Mercury; I.R. Jonasson and R.W. Boyle, Royal Society, Canadian Symposium on Mercury in Man's Environment, Ottawa, Ont., Feb (1971).

(13) Guidelines for Surface Water Quality, Vol. 1 - Inorganic Chemical Substances: Mercury; S.W. Reeder, A. Demayo and M.C. Taylor, Water Quality Branch, Inland Waters Directorate, Ottawa, Ont. (1979).

(14) Mercury in the Atlantic Provinces; R.C.H. Wilson and I.C. Travers, EPS-5-AR-77-10, Environmental Protection Service, Halifax, N.S., Nov (1976).

APPENDIX I

SAMPLING SITES

SAMPLING SITE #	DESCRIPTION	NAQUADAT #
NEW BRUNSWICK		
1	Glasier Lake, 200 m above outlet of St. Francis River (Sampled in 1981)	01NB01AD0004 51NB01AD0004
2	Madawaska River Headpond 50 m from Fraser Pumping Station #2 (Sampled in 1981)	01NB01AD0005
3	Saint John River, 150 m above dam, Grand Falls (Sampled in 1979 and 1980)	01NB01AF0005
4	Saint John River at Grand Falls Headpond, 500 m above dam, Madawaska County (Sampled in 1979 and 1981)	01NB01AF0006 52NB01AF0006
5	Aroostook River at Canada-USA Border (center of River), Victoria County (Sampled in 1979 and 1980)	01NB01AG0002 51NB01AG0002
6	Lake Nictau at centre of Westerly Basin, Restigouche County (Sampled in 1981)	01NB01AH0008 51NB01AH0008
7	Saint John River 150 m above dam, Beechwood, Carleton County (Sampled in 1981)	01NB01AJ0003 51NB01AJ0003
8	Saint John River at Mactaquac Headpond, 100 m above headland (Sampled in 1981)	01NB01AK0012 51NB01AK0012
9	Grand Lake about 700 m from Jemseg River at black channel marker (Sampled in 1981)	01NB01AØ0019 51NB01AØ0019
10	Saint John River at Lower Gagetown from ferry in midstream, Queens County (Sampled in 1979 and 1980)	00NB01AP0035

APPENDIX I Cont'd

SAMPLING SITE #	DESCRIPTION	NAQUADAT #
11	Saint John River, about 1.3 km below ferry at center Westfield (Sampled in 1981)	02NB01AP0013 52NB01AP0013
12	Kennebecasis Bay near Gondola Point between Wheatons Pt and Oliver Pt, 150 m from Wheatons Point (Sampled in 1981)	02NB01AP0014 52NB01AP0014
13	Saint John Harbour (Courtenay Bay), 1250 m WSW of confluence of Little River (Sampled in 1979)	03NB01AP0001 53NB01AP0001
14	Saint John Harbour, 50 m N of Pier 9 (Sampled in 1980)	02NB01AP0012 53NB01AP0012
15	Magaguadavic Lake 1000 m east of Hills Head in center of basin (Sampled in 1981)	01NB01AQ0028 51NB01AQ0028
16	St. Croix River at International Bridge, Milltown, Charlotte County (Sampled in 1979 and 1980)	00NB01AR0001
17	St. Croix River at confluence of Dennis Stream, Charlotte County (Sampled in 1980)	52NB01AR0002
18	Spednic Lake outlet at center opposite confluence of Casey Brook (Sampled in 1981)	01NB01AR0016 51NB01AR0016
19	Restigouche River at Rafting Ground Brook (WSC Gauge), Restigouche County (Sampled in 1979 and 1980)	00NB01BJ0056
20	Restigouche River (Dalhousie Harbour) 850 m NW of Dalhousie Island Lighthouse, Restigouche County (Sampled in 1979 and 1980)	03NB01BJ0001 53NB01BJ0001

APPENDIX I Cont'd.

SAMPLING SITE #	DESCRIPTION	NAQUADAT #
21	Nepisiquit River at Nepisiquit Falls Headpond, 300 m above dam (Sampled in 1981)	01NB01BK0010 51NB01BK0010
22	Nepisiquit River at Hwy 360 Bridge near NLU Mine, Gloucester County (Sampled in 1979 and 1980)	00NB01BK0026
23	Nepisiquit River 200 m below old Hwy 11 Bridge, Bathurst, Gloucester County (Sampled in 1979)	52NB01BK0002
24	Bathurst Harbour near mouth of Nepisiquit River, Gloucester County (Sampled in 1980)	02NB01BK0001 52NB01BK0001
25	Bathurst Harbour, 700 m NNW of Daly Point, Gloucester County (Sampled in 1979)	03NB01BL0001 53NB01BL0001
26	Southwest Miramichi River at Hwy Bridge, Blackville, Northumberland County (Sampled in 1979 and 1980)	00NB01BØ0001
27	Northwest Miramichi River at Wayerton from Hwy 430 Bridge, Northumberland County (Sampled in 1979 and 1980)	00NB01BQ0044
28	Miramichi River at Chatham, 750 m below Hwy 11 Bridge, Northumberland County (Sampled in 1980)	02NB01BØ0001 52NB01BØ0001
29	Miramichi River near Loggieville, 1500 m West of St. Andrews Point, Northumberland County (Sampled in 1979)	03NB01BØ0001
30	Petitcodiac Lake at center, 850 m above Moncton Causeway (under transmission lines) (sampled in 1981)	01NB01BU0001 51NB01BU0001

APPENDIX I Cont'd

SAMPLING SITE #	DESCRIPTION	NAQUADAT #
NOVA SCOTIA		
31	Annapolis River at Bridge, 650 m south of Hwy 1 (WSC Gauge), Wilmot Station (Sampled in 1979, 1980 and 1981)	00NS01DC0001
32	Annapolis River near Mochelle at Center (Sampled in 1979, 1980 and 1981)	02NS01DC0004 52NS01DC0004
33	Shubenacadie River 400 m above Nine Mile River at Bridge, Elmsdale (Sampled in 1979 and 1980)	00NS01DG0008
34	Shubenacadie Lake, 2 km above inlet at Centre, Halifax County (Sampled in 1981)	01NS01DG0031 51NS01DG0031
35	Shubenacadie Lake in upper basin 300 m NE of Cochrane Point, Hants County (Sampled in 1981)	01NS01DG0032 51NS01DG0032
36	Salmon River at Park Street Extension Bridge, Truro, Colchester County (Sampled in 1979)	02NS01DH0002 52NS01DH0002
37	East Brook at Hwy 2 Bridge, Southampton, Cumberland County (Sampled in 1980)	00NS01DL0007
38	River Philip at Hwy 204 Bridge, Oxford, Cumberland County (Sampled in 1979 and 1980)	00NS01DN0002
39	East River of Pictou at Indian Cross Point 700 m from right bank (Sampled in 1981)	02NS01DP0004 52NS01DP0004
40	Pictou Harbour near Town Point Wharf, Pictou County (Sampled in 1979)	03NS01DP0001 53NS01DP0003

APPENDIX I Cont'd

SAMPLING SITE #	DESCRIPTION	NAQUADAT #
41	Pictou Harbour between jetty and causeway, 200 m from sluice gates (Sampled in 1981)	03NS01DP0003 53NS01DP0003
42	Kejimkujik Lake, 500 m NE of Freeman Island, Queens County (Sampled in 1981)	01NS01ED0049 51NS01ED0049
43	Lake Rossignol, 650 m above dam at Center, Queens County (Sampled in 1981)	01NS01ED0050 51NS01ED0050
44	Liverpool Bay 1 km above Mersey Pulp Mill at Fort Point Shoal Channel Marker, Queens County (Sampled in 1980)	03NS01ED0001 53NS01ED0001
45	Medway River at Bridge (WSC Gauge), Charleston, Queens County (Sampled in 1979 and 1980)	00NS01EE0001
46	Ponhook Lake at center of outlet 600 m above Round Islands, Queens County (Sampled in 1981)	01NS01EE0003 51NS01EE0003
47	Lahave River at Yacht Club near West Lahave, Lunenburg County (Sampled in 1980)	03NS01EF0002 53NS01EF0002
48	Halifax Harbour (Eastern Passage) near Shearwater Wharf, Halifax County (Sampled in 1979 and 1980)	03NS01EJ0015 53NS01EJ0015
49	St. Mary's River at Bridge (WSC Gauge), Stillwater, Guysborough County, (Sampled in 1979 and 1980)	00NS01E∅0001
50	Chedabucto Bay, 3 km ESE of Sting Point, Guysborough County (Sampled in 1979 and 1980)	03NS01ER0001 53NS01ER0001
51	Strait of Canso at Port Hawkesbury 650 m West of Public Wharf (Sampled in 1981)	03NS01FA0004 53NS01FA0004

APPENDIX 1 Cont'd

SAMPLING SITE #	DESCRIPTION	NAQUADAT #
52	Northeast Margaree River at Bridge, Margaree Valley (WSC Gauge), Inverness County (Sampled in 1979 and 1980)	00NS01FB0001
53	Lake Ainslie, 500 m from southerly tip, Inverness County (Sampled in 1979 and 1980)	01NS01FB0002 51NS01FB0002
54	St. Patricks Channel at Baddeck about 200 m SW of Lighthouse on westerly end of Kidston Island (Sampled in 1981)	02NS01FF0001 52NS01FF0001
55	Salmon River at Salmon River, Cape Breton County (Sampled in 1979 and 1980)	00NS01FJ0001
56	Mira River at Marion Bridge, 500 m below Hwy 327 Bridge at center, Cape Breton County (Sampled in 1981)	00NS01FJ0020 50NS01FJ0020
57	Sydney Harbour 200 m SW of Engineering and Drydock, Cape Breton County (Sampled in 1979 and 1980)	03NS01FJ0001 53NS01FJ0001
PRINCE EDWARD ISLAND		
58	Carruthers Brook (Mill River) at WSC Gauge in Bloomfield Park north of St. Anthony, Prince County (Sampled in 1979 and 1980)	00PE01CA0001
59	Mill River 1 km below Hwy 12 Bridge at centre of Estuary, Prince County (Sampled in 1981)	02PE01CA0020 52PE01CA0020
60	Dunk River at road Bridge, 5.5 km east of Central Bedeque, Prince County (Sampled in 1979 and 1980)	00PE01CB0001

APPENDIX I Cont'd

SAMPLING SITE #	DESCRIPTION	NAQUADAT #
61	Malpeque Bay, 1850 m S61°W from boat launching site at end of Beech Point, Prince County (Sampled in 1979 and 1980)	03PE01CB0005 53PE01CB0005
62	Summerside Harbour 100 m S25°W from southwestern corner of Queens Wharf, Prince County (Sampled in 1979 and 1980)	03PE01CB0006 53PE01CB0006
63	New London Bay, 1200 m East of McEwens Island, Queens County (Sampled in 1981)	03PE01CB0007 53PE01CB0007
64	West River at Center of confluence of Ferguson Creek, Queens County (Sampled in 1981)	02PE01CC0055 52PE01CC0055
65	North River at Center, 100 m above Cable Crossing, Queens County (Sampled in 1981)	02PE01CC0056 52PE01CC0056
66	Charlottetown Harbour, 80 m S65°W from southwestern corner of MOT Marine Terminal, Queens County (Sampled in 1979 and 1980)	03PE01CC0005 53PE01CC0005
67	Morell River from road Bridge, 1 km west of Bangor, Kings County (Sampled in 1979 and 1980)	00PE01CD0003
68	Georgetown Harbour in center of Channel between Wightmans Point and Thrumpcap Spit, Kings County (Sampled in 1981)	03PE01CE0002 53PE01CE0002
NEWFOUNDLAND		
69	Torrent River at Bristol's Pool, WSC Gauge (Sampled in 1980)	00NF02YC0001
70	Harry's River at Black Duck from Hwy Bridge, WSC Gauge (Sampled in 1980)	00NF02YJ0001

APPENDIX I Cont'd

SAMPLING SITE #	DESCRIPTION	NAQUADAT #
71	Port Harmon at edge of channel, 600 m SW of Public Wharf (Sampled in 1980)	03NF02YJ0001 53NF02YJ0001
72	Humber Arm at Church Cove, 100 m NW of Gulf Oil Pier (Sampled in 1980)	03NF02YK0001 53NF02YK0001
73	Indian Brook near Springdale, WSC Gauge (Sampled in 1980)	00NF02YM0001
74	Exploits River at Grand Falls (Sampled in 1980)	00NF02YØ0001
75	Lewisporte Harbour, 100 m West of Main Wharf (Sampled in 1980)	03NF02YØ0001 53NF02YØ0001
76	Pipers Hole River at Mothers Brook (Sampled in 1980)	00NF02ZH0001
77	Rocky River at Hwy 6, Colinet (Sampled in 1980)	00NF02ZK0001
78	St. John's Harbour, 50 m NNE of SW Corner of Pier 51 (Sampled in 1980)	03NF02ZM0001 53NF02ZM0001

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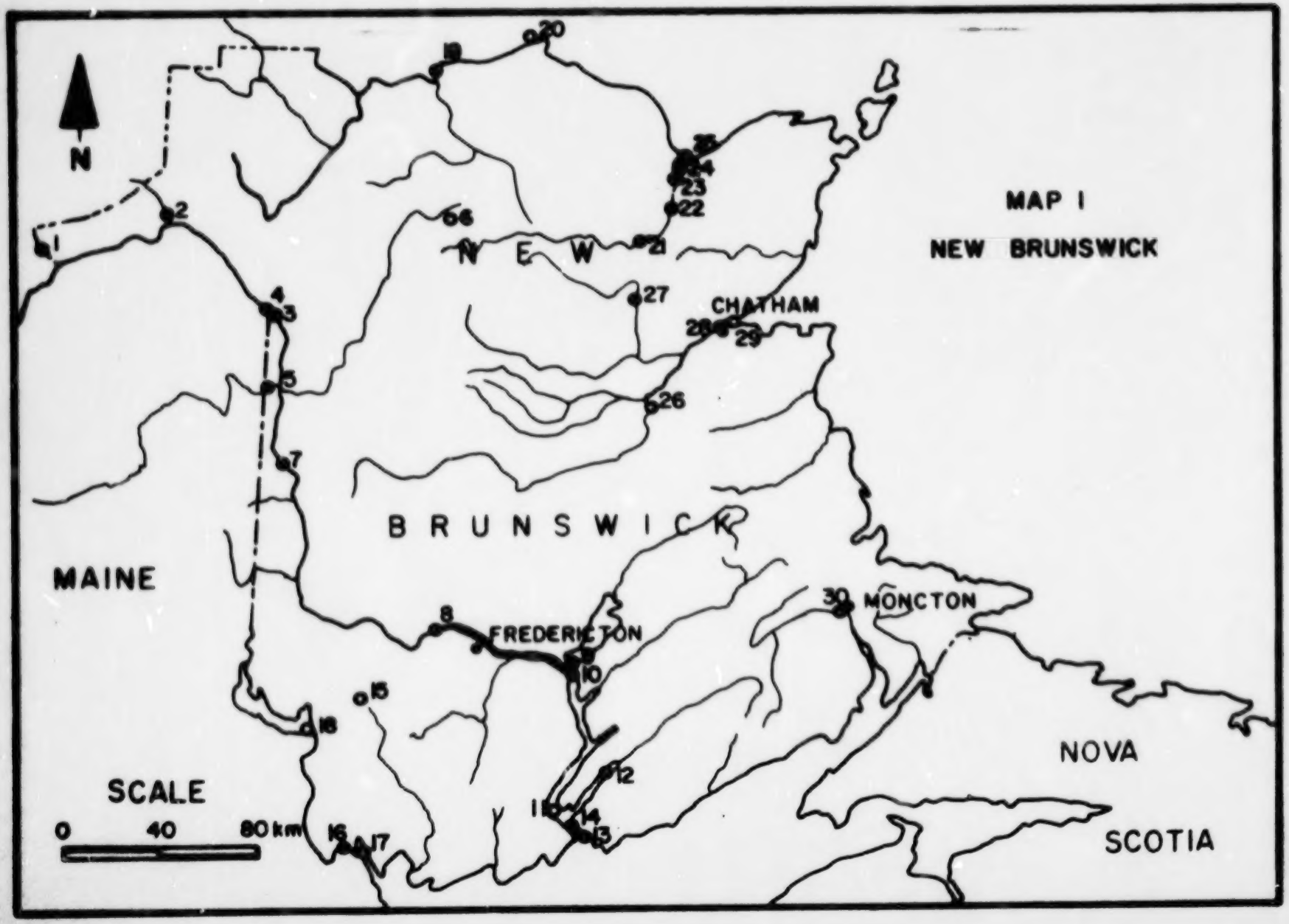
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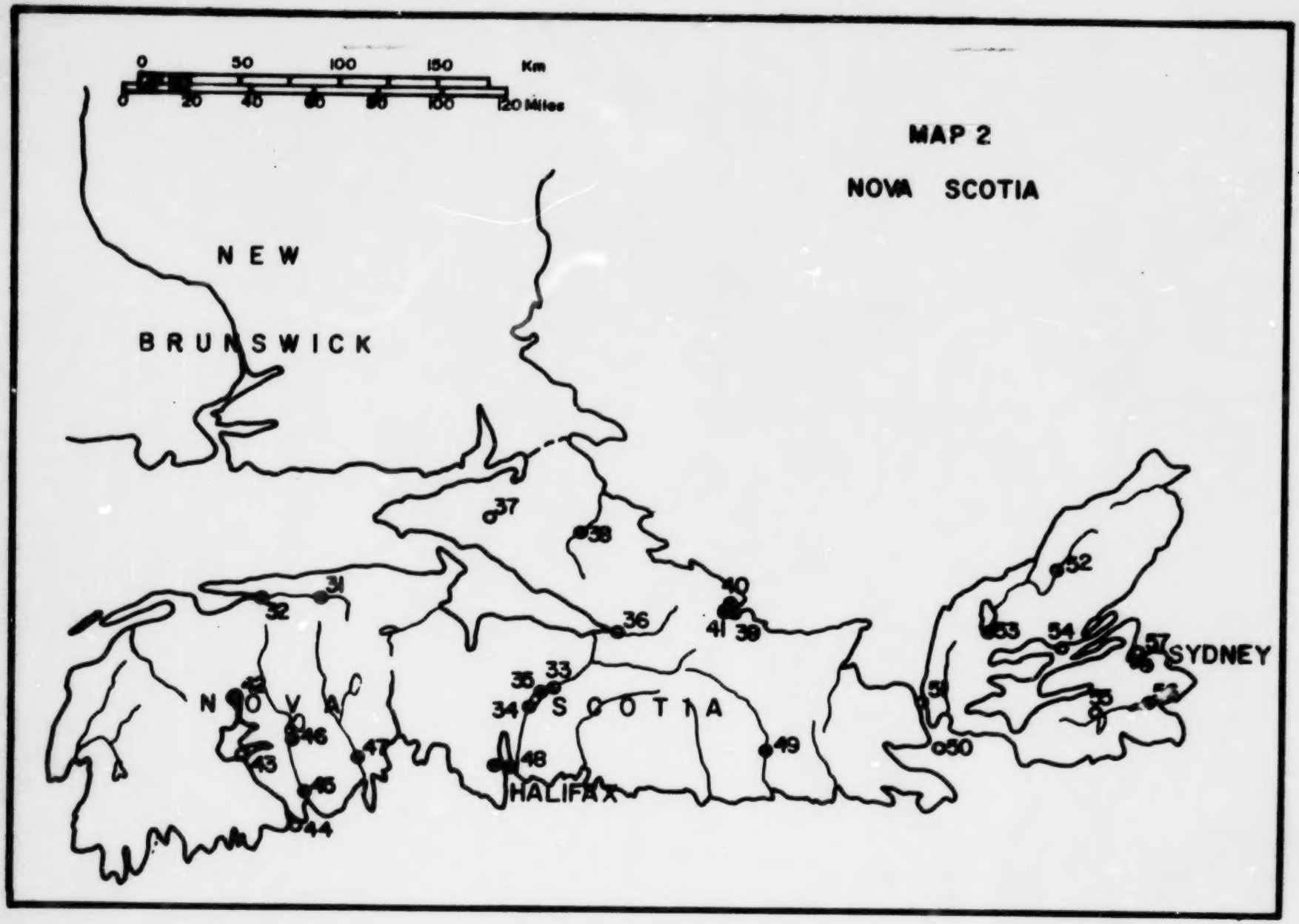
SCALE
0 40 80 km


0 50 100 150 Km
0 20 40 60 80 100 120 Miles
MAP 2
NOVA SCOTIA
NEW
BRUNSWICK
NOVA SCOTIA
HALIFAX
SYDNEY
31
32
37
38
36
40
41
39
52
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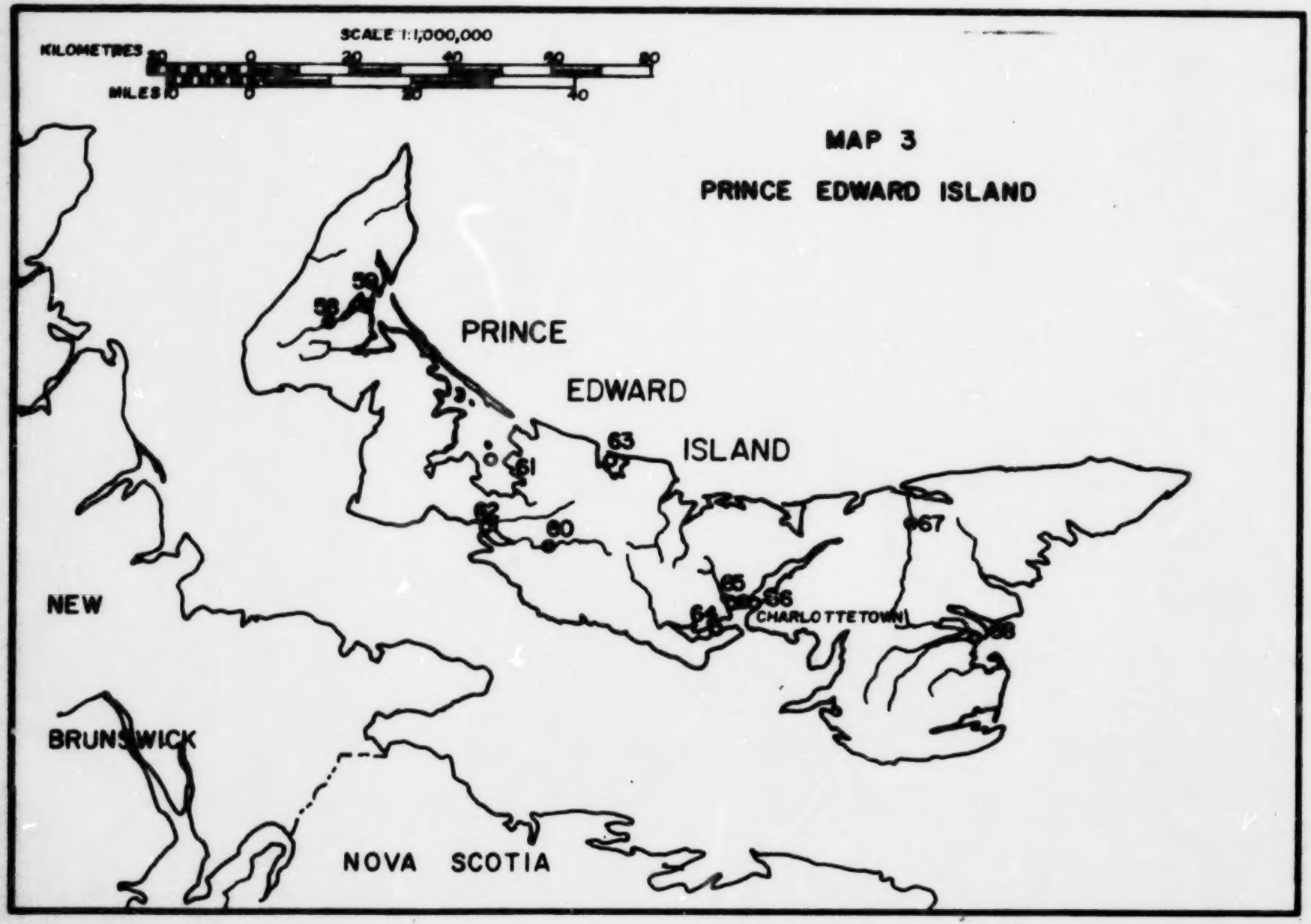
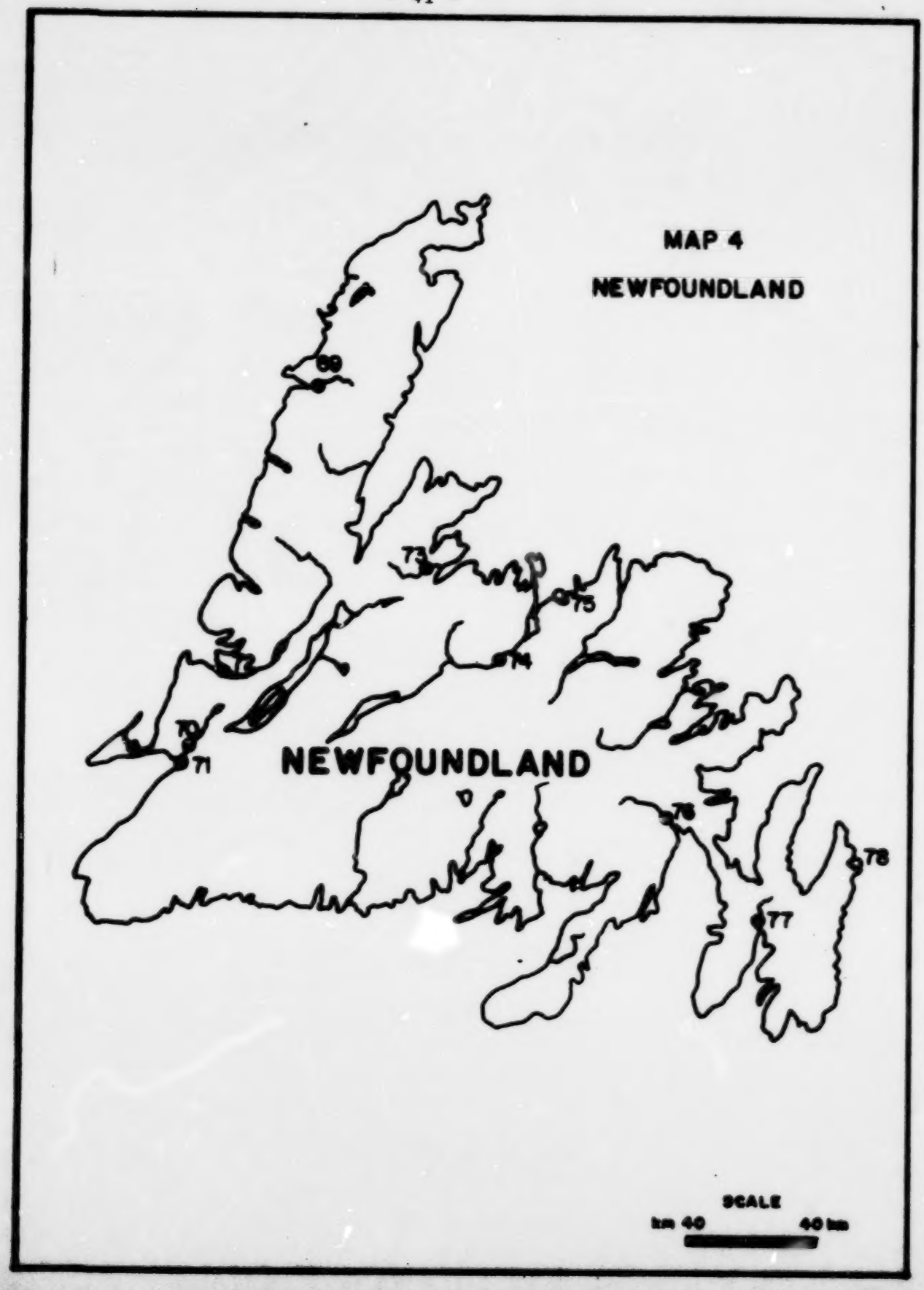
44


SCALE 1:1,000,000
KILOMETRES 20 0 20 40 60 80
MILES 10 0 20 40
MAP 3
PRINCE EDWARD ISLAND
PRINCE
EDWARD
ISLAND
NEW
BRUNSWICK
NOVA SCOTIA
CHARLOTTETOWN
58
59
61
63
60
67
65
66
64
68


MAP 4
NEWFOUNDLAND
NEWFOUNDLAND
SCALE
km 40
40 km

POOR

QUALITY

ORIGINAL